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# Local Wind Patterns in Wildcat Canyon

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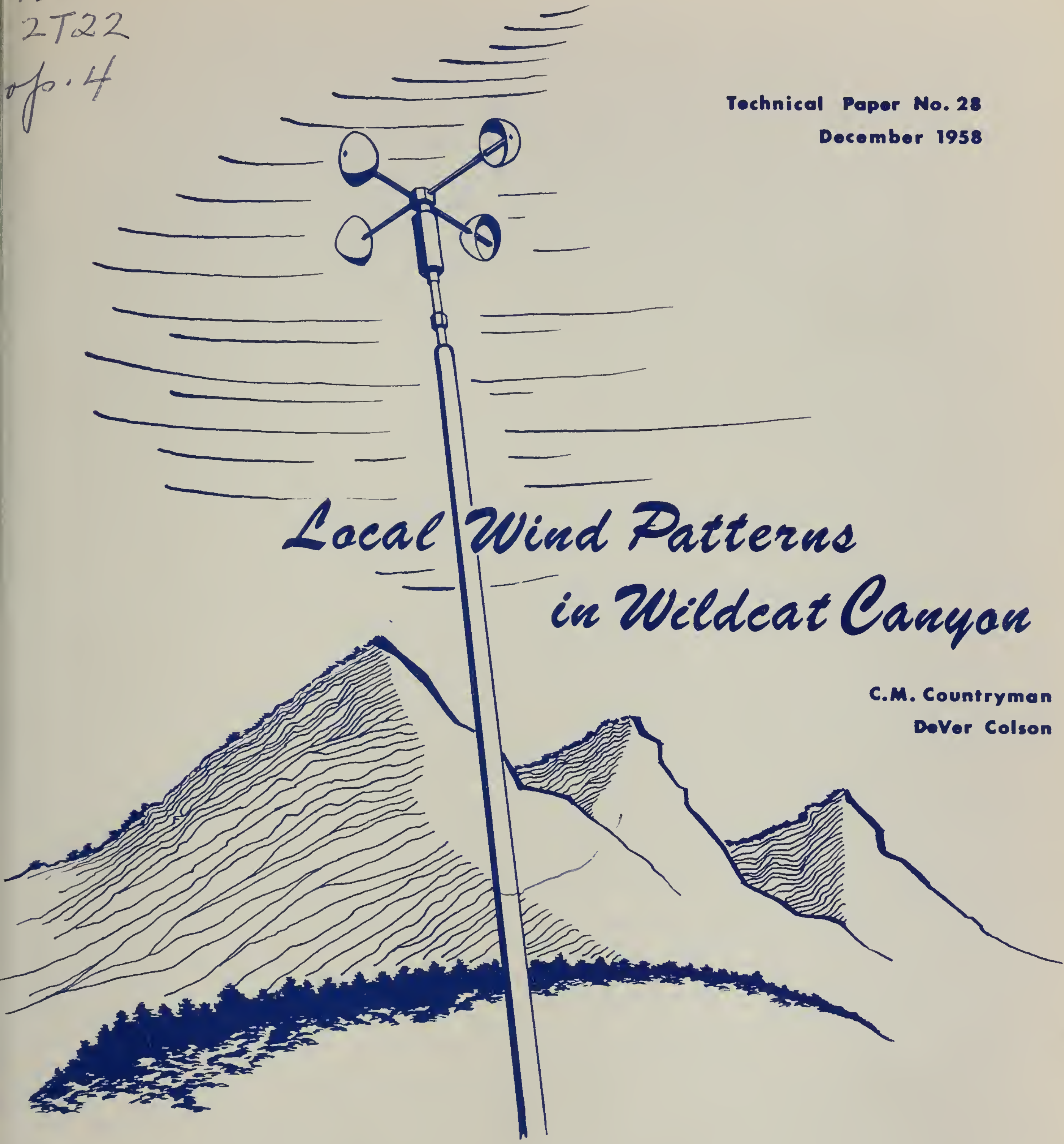

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Keith Arnold, Director.

## ABSTRACT

For a better understanding of fire behavior, fire control men need more detailed information about local wind conditions. To explore the problems concerned with providing this information through wind surveys, we laid out an intensive network of wind-recording instruments in a small canyon in San Diego County. The analysis reported here shows the kind of information that can be derived from such a survey. From the analysis we learned:

1. Ground conditions frequently exert a major control on wind patterns, only strong upper air patterns extend their influence to the surface.
2. Field studies of local wind patterns can identify problems for laboratory studies of air flow over topographic models to develop the basic laws controlling surface wind flow under various topographic and synoptic weather conditions.

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# LOCAL WIND PATTERNS IN WILDCAT CANYON

by

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## The Problem

For many years fire control men and fire weather forecasters have recognized that sound information about local patterns of air movement is a "must" for effective forest fire control. Meteorological information for use in fire weather forecasting and for use on going fires is now obtained from relatively few and widely spaced weather stations--most of which are not equipped with recording instruments. This system of climatic stations provides adequate information for general weather forecasts over a wide area, but the usual momentary samples of weather two or three times a day do not provide sufficient data to define local weather patterns. Then too, little is known as to how well the climatic station actually represents the weather in the surrounding area. Consequently, how the wind and other weather factors vary on the slopes and in the canyons of western mountains remains largely unknown to forester and meteorologist alike.

One way to obtain the needed information is by means of concerted and comprehensive fireclimate surveys. This report shows some of the kinds of information that can be derived from a wind survey.

## The Survey

In 1954 an experimental wind survey was made as a major part of the field program of Operation Firestop. Primary purpose of the survey was to explore the problems of measuring and recording climatic factors in the field to learn something of the analysis, procedures, and data needed to provide the knowledge required about local weather. Procedures and instrumentation used in the survey and the problems encountered have already been described.[1]

The survey was conducted in Wildcat Canyon on the Camp Pendleton area in San Diego County, California. Wildcat Canyon is about

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[1] The Wind Survey, Operation Firestop, Technical Report No. 2, U. S. Forest Service, San Francisco. 18pp., illus. May 1956.

4 miles long and is typical of the many rugged canyons in the Coast Range of southern California (fig. 1). The canyon opens into the broad San Mateo drainage a few miles from the Pacific Ocean. Elevation at the canyon mouth is about 400 feet. The canyon extends about 2 miles to the southeast, rising quickly to about 1,500 feet. At this point the canyon divides into two branches. The main, or northern branch, makes a sharp turn to the northeast, continuing in this direction for nearly a half mile, and then turns sharply to the east for another half mile. Above this point the canyon is not very sharply defined. Margarita Peak overlooks the canyon and is located directly above the upper drainage branches.

North slopes are covered by dense stands of scrub oak, sumac, and ceanothus, 8 to 10 feet high, at the higher elevations and by light to moderate stands of chamise at lower elevations. South slopes support a scattered sage cover at low elevations, and light stands of chamise 4 to 5 feet high at upper elevations.

Twenty instrument stations were established in the drainage area at various elevations and topographic positions (fig. 2, table 1). Each of the stations was equipped with an automatic wind speed and direction recorder. At most stations the wind was measured at an equivalent height of 20 feet above open level ground. Observations at other heights were made at selected stations. In compiling the data, the prevailing wind direction and the average wind speed were determined for each hour at each station.

## Average Wind Flow Patterns

A westerly wind was the most frequent wind direction during the July through September survey period (fig. 3). This direction corresponds to the up-canyon flow that was usual during the daytime hours. Next most frequent directions were southeast and east--the down-canyon direction.

Wind direction frequencies also show the effect of topography on wind direction. The stations at the more exposed locations on ridges and peaks (1, 2, 4, 7, 11, 12, and 15) show considerable more scatter in wind direction than the stations at lower elevations and deeper in the canyon (3, 8, 9, 13, 14, 16, 18, 18a, and 19) where the wind came more from only two directions--either up canyon or down canyon (fig. 2).

The tendency for the wind to become more two-directional closer to the canyon bottom is well illustrated by the stations at the mouth of the canyon. Station 18a at 20 feet above the ground shows winds almost entirely from two directions while station 18 at 50 feet has considerable scatter in wind direction. Station 19, suspended 150 feet above the canyon bottom, shows still more variation in direction.

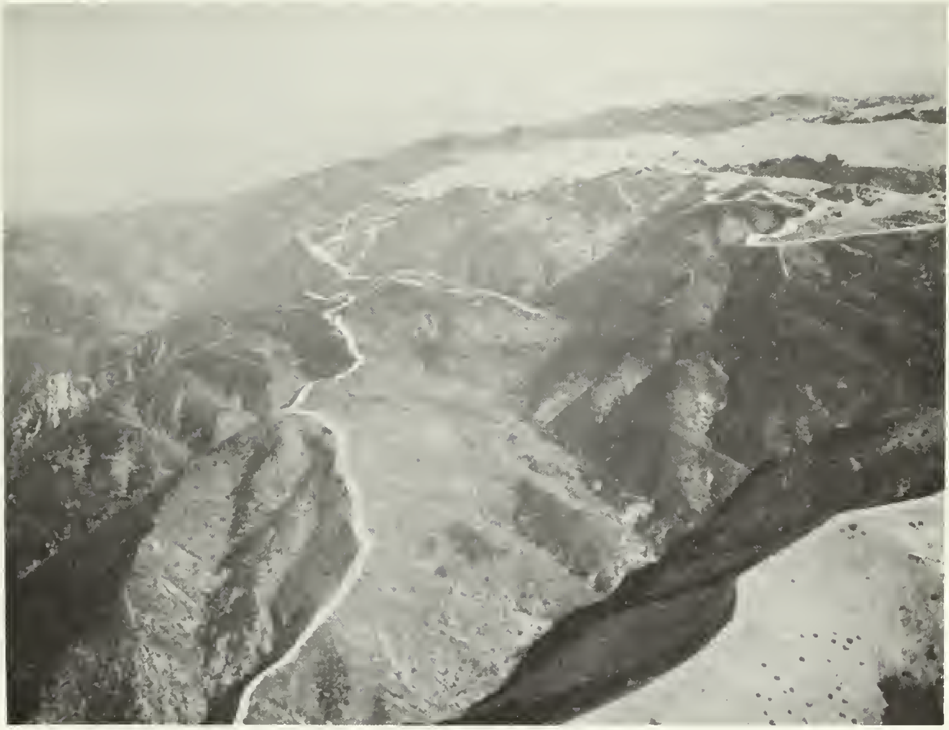

Figure 1.--Wildcat Canyon wind survey area looking east up-canyon.

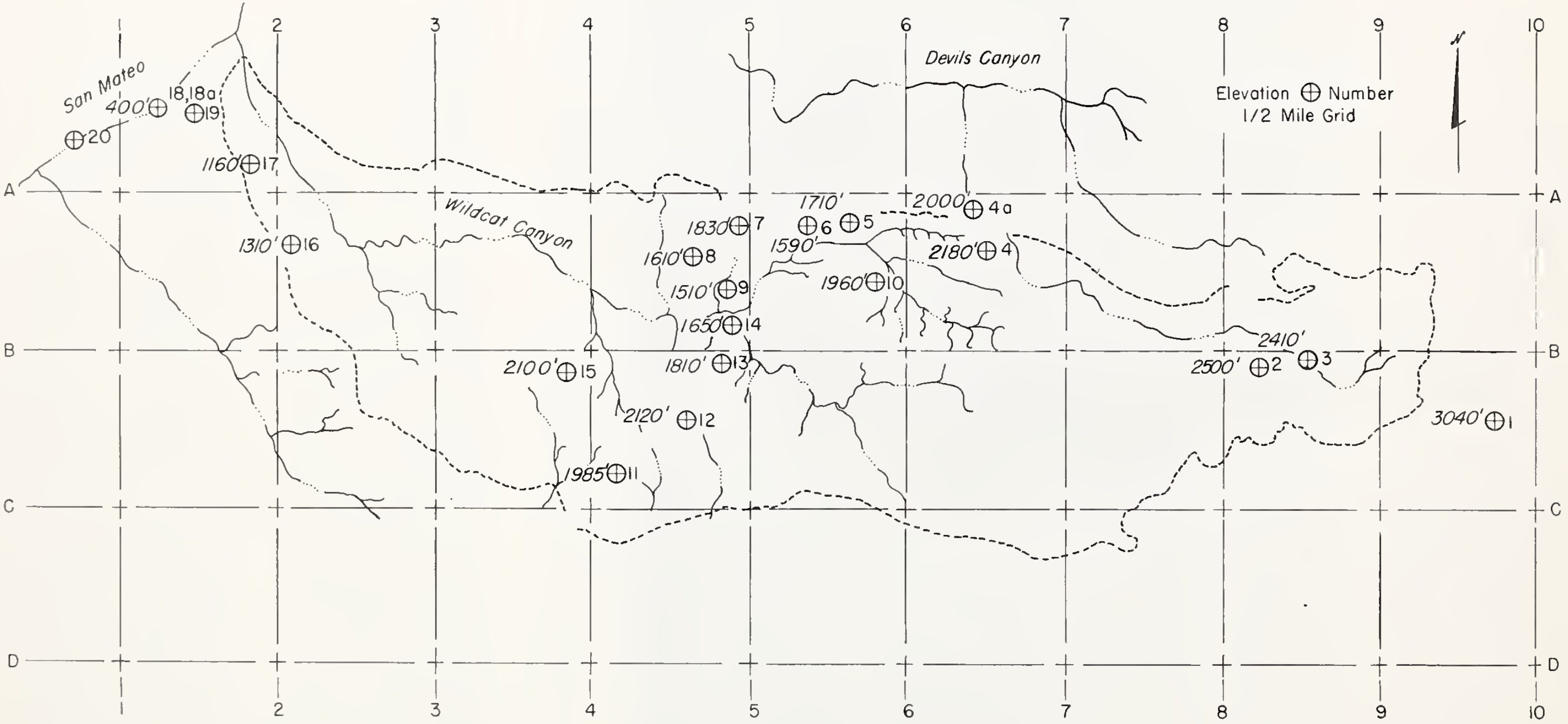

Figure 2. --Wildcat Canyon wind survey area.

Table 1. --Location of wind survey stations

| Station | Remarks | Elevation | Location coordinates (See fig. 2) |
|---|---|---|---|
| | | Feet | |
| 1 | Margarita Peak lookout | 3,040 | C 10 |
| 2 | Crest of ridge | 2,500 | C 9 |
| 3 | Bottom of ravine adjacent to Station 2 | 2,410 | C 9 |
| 4 | Crest of ridge | 2,180 | B 7 |
| 4a | Crest of ridge opposite Station 4 | 2,000 | B 7 |
| 5 | Bottom of saddle | 1,710 | B 6 |
| 6 | Cable across canyon (5 anemometers) | 1,590 | B 6 |
| 7 | North rim of Wildcat Canyon | 1,830 | B 5 |
| 8 | North side of Wildcat Canyon | 1,610 | B 5 |
| 9 | Bottom of Wildcat Canyon | 1,510 | B 5 |
| 10 | Ridge in center of Wildcat Canyon drainage system | 1,960 | B 6 |
| 11 | Established for test fire weather measurements. Not included in wind survey network | 1,985 | C 5 |
| 12 | South run of Wildcat Canyon opposite Station 7 | 2,120 | C 5 |
| 13 | South side of Wildcat Canyon | 1,810 | C 5 |
| 14 | Bottom of Wildcat Canyon | 1,650 | B 5 |
| 15 | Crest of ridge | 2,100 | C 4 |
| 16 | Ridge near mouth of canyon | 1,310 | B 3 |
| 17 | Lower end of same ridge as Station 16 | 1,160 | A 2 |
| 18 | Mouth of Wildcat Canyon | 400 | A 2 |
| 18a | Mouth of Wildcat Canyon (Anemometer height: 50 feet) | 400 | A 2 |
| 19 | Cable across canyon (5 anemometers) | 400 | A 2 |
| 20 | Basin west of canyon mouth | 400 | A 1 |

Highest average wind speeds occurred at Margarita Peak (Station No. 1), which was at the highest elevation of any of the stations and well exposed to winds aloft. Strong wind speeds are also evident at the stations near the mouth of the canyon (16, 18, 18a, 19, and 20) since these stations are well exposed to main drainage winds.

## Diurnal Variations in the Wind Flow Patterns

In early morning hours the wind speeds were generally light except on Margarita Peak and at stations near the mouth of the canyon, where downslope drainage is well channelled (figs. 4 and 5). Morning winds, like the general wind flow, were more variable in direction at the exposed stations than at others where down-canyon flow was most frequent.

The transition between the down-canyon and up-canyon flow patterns became evident between 0600 and 0800 hours (fig. 6). By the 0900-1100 period (fig. 7), a definite up-canyon flow pattern, with increasing wind speeds at all stations except Margarita Peak, was evident. Strongest wind speeds occurred at nearly all stations during the 1200 to 1400 period (fig. 8). Strong winds continued through the 1500 to 1700 period (fig. 9). The transition back to down-canyon flow showed up in the 1800-2000 time period (fig. 10). By 2100-2300, the nighttime flow pattern has again become well established (fig. 11).

We tried, but failed, to show some relation between the actual transition times and general weather patterns. The scatter in the data was too large to show any significant change in transition times.

## Wind Flow Patterns and General Weather

There was little change in the general weather pattern in southern California during the period of the survey. Pressure gradients were weak and the winds aloft for the most part were light and variable. It was possible, however, to select a few days on which the winds aloft were stronger than usual. Three groups of these days were selected--those in which the winds in the 5,000- to 10,000-foot layer were predominantly from the east, the west, or the south. The surface wind data were separated by daytime hours (0800 to 1800) and nighttime hours (1900 to 0700) for each of these three upper wind patterns.

Daytime surface winds from westerly directions were less frequent at the higher stations (1, 2, 4, 12, and 15) when winds aloft were easterly (fig. 12) than when they were from the west (fig. 13). The lower and more sheltered stations (3, 8, 9, 13, and 14) show little of this influence. At stations 18, 18a, and 19 the usual strong up-canyon winds in the daytime seem to overwhelm any effect of easterly winds aloft. The effect of southerly winds aloft is most noticeable at stations 18 and 19, which are more open to southerly flow (fig. 14).

Nighttime surface winds were more responsive to winds aloft. With easterly flow aloft, the number of surface north and northeast winds increased noticeably (fig. 15). Furthermore, westerly winds aloft easily overcame the normally light down-canyon winds, resulting in a marked increase in the number of westerly winds at the surface (fig. 16). Southerly flow aloft resulted in an appreciable increase in the number of south and southeast winds at the surface and a decrease in westerly winds (fig. 17).

## CONCLUSION

The analysis reported here has utilized the large mass of data accumulated during the Operation Firestop wind survey only in detail sufficient to show that local wind patterns and the way they are affected by general weather and topography can be determined by surveys of this type. This first analysis indicates that local conditions frequently exert a major control on local wind patterns. If this is generally true then only strong patterns in upper air conditions can be expected to extend their influence to ground level. Therefore, localized data becomes a "must" for accurate fire weather and fire behavior prediction.

Although wind surveys probably can work out enough detailed knowledge of wind patterns for effective fire control, making a survey for every drainage would not be economic. By sampling distinctive topographic types, however, wind surveys can identify major wind behavior problems. Then controlled laboratory studies with topographic models can be used to establish the basic relationships creating and controlling local wind patterns. Once these relationships are known and understood, extension of this knowledge to other areas will be both practical and feasible.

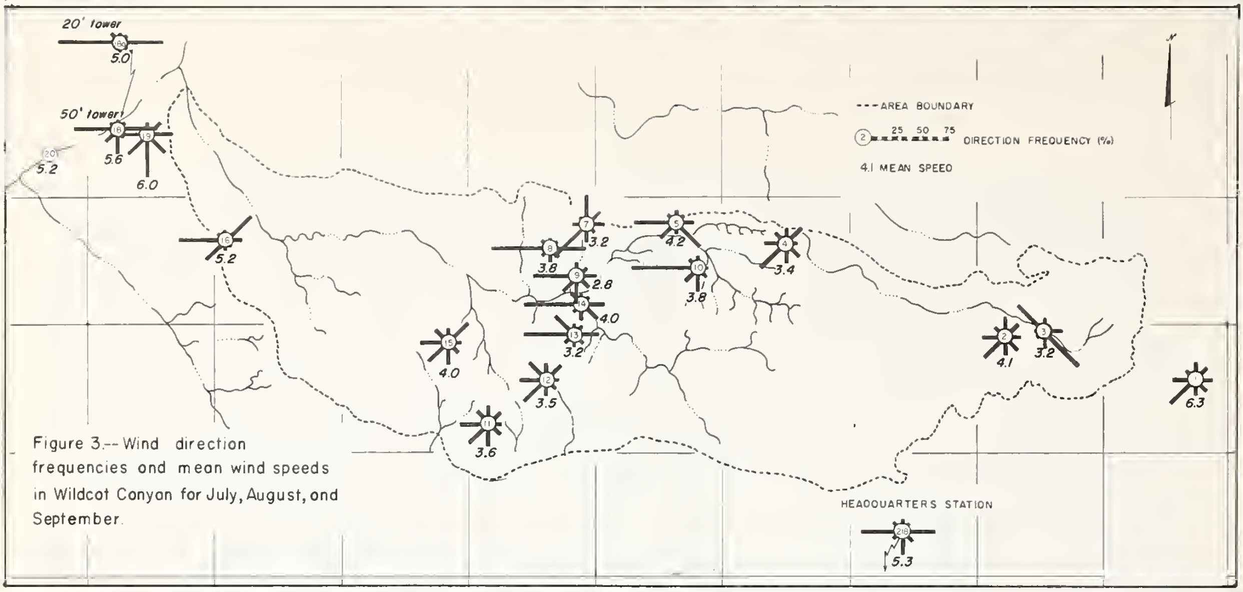

Figure 3.-- Wind direction frequencies and mean wind speeds in Wildcat Canyon for July, August, and September.

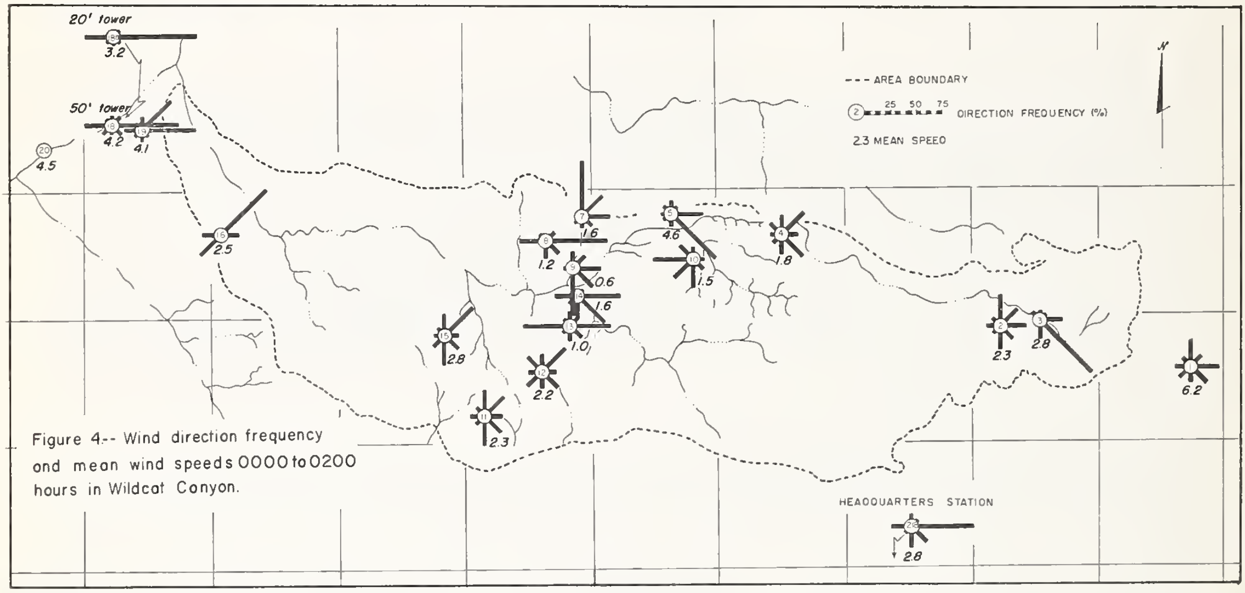

Figure 4.-- Wind direction frequency and mean wind speeds 0000 to 0200 hours in Wildcat Canyon.

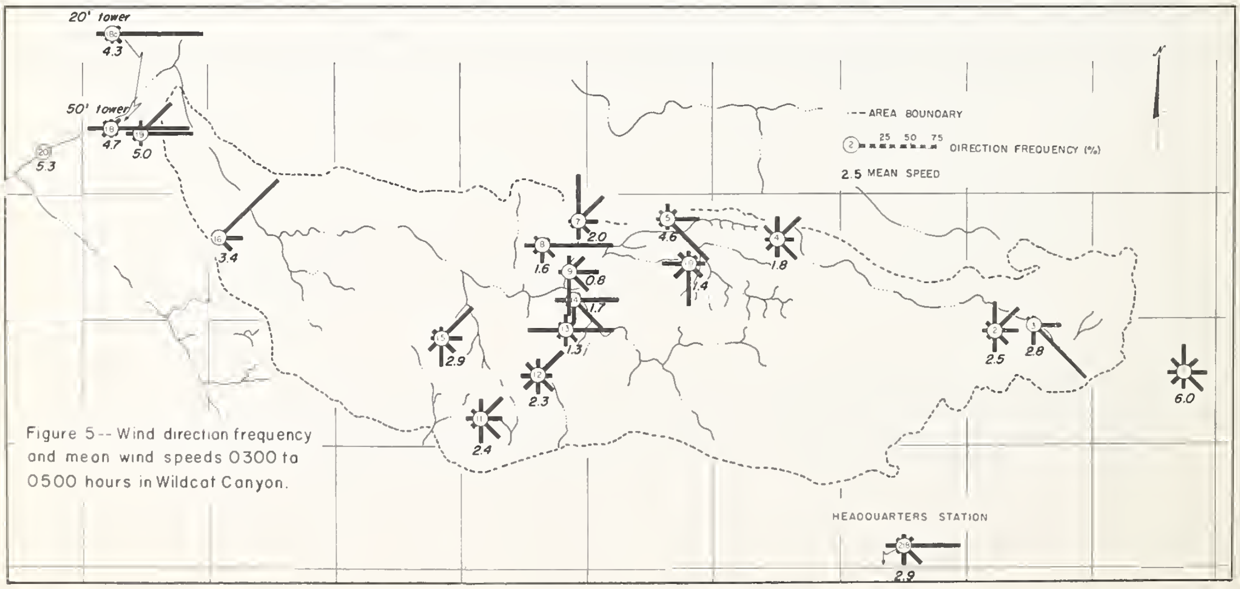

Figure 5 -- Wind direction frequency and mean wind speeds 0300 to 0500 hours in Wildcat Canyon.

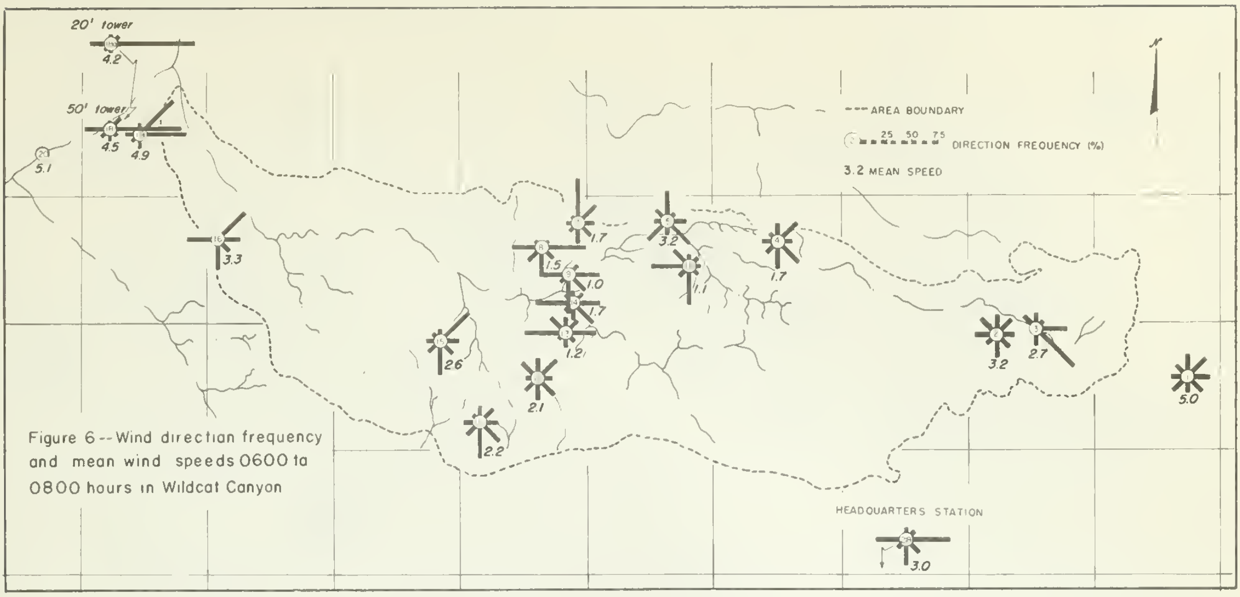

Figure 6--Wind direction frequency and mean wind speeds 0600 to 0800 hours in Wildcat Canyon

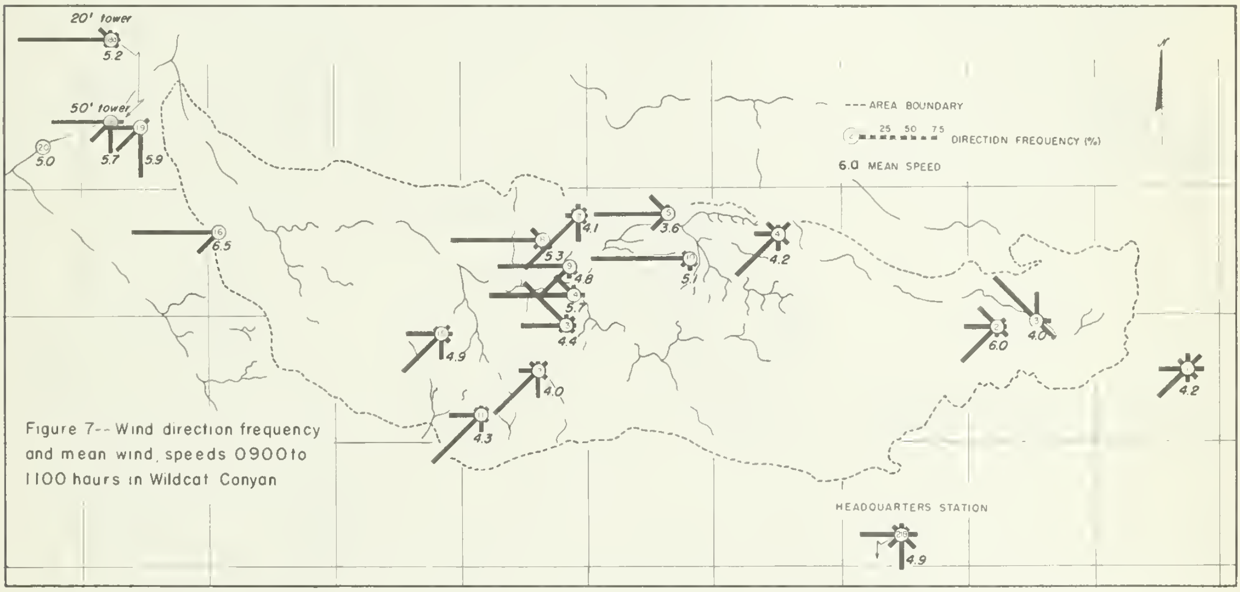

Figure 7--Wind direction frequency and mean wind speeds 0900 to 1100 hours in Wildcat Canyon

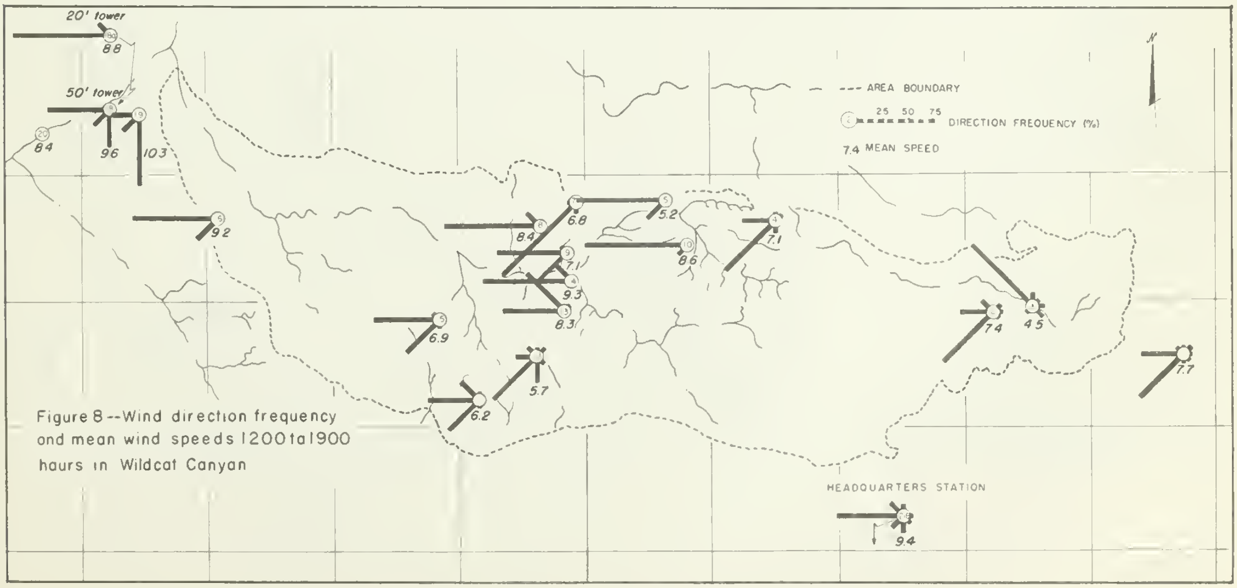

Figure 8--Wind direction frequency and mean wind speeds 1200 to 1900 hours in Wildcat Canyon

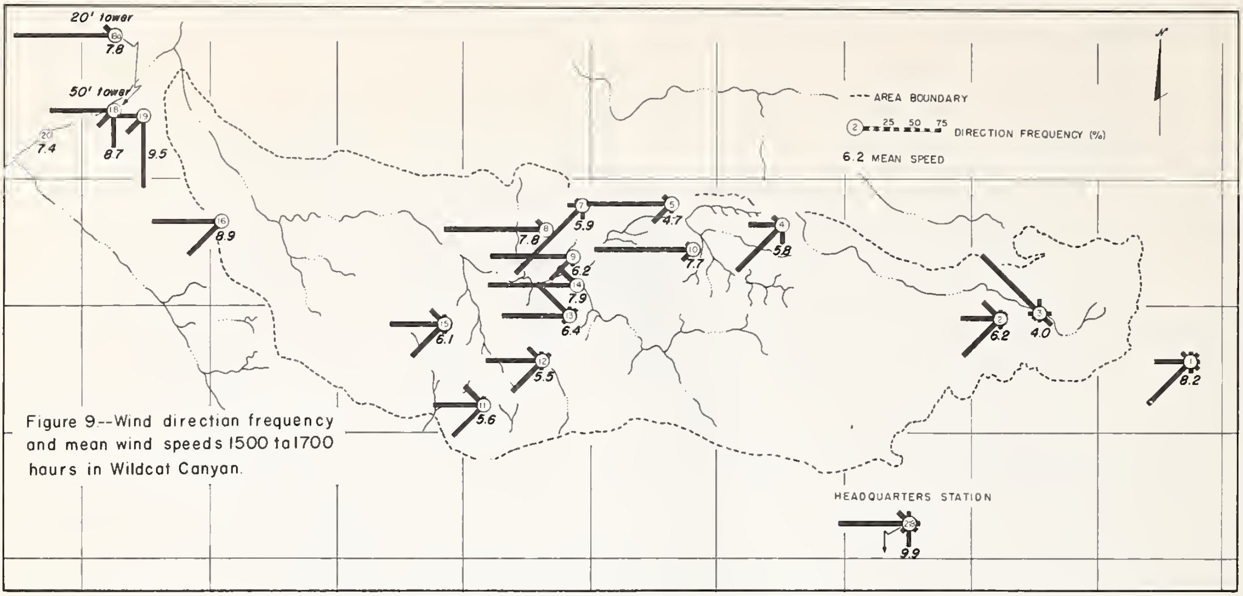

Figure 9--Wind direction frequency and mean wind speeds 1500 to 1700 hours in Wildcat Canyon.

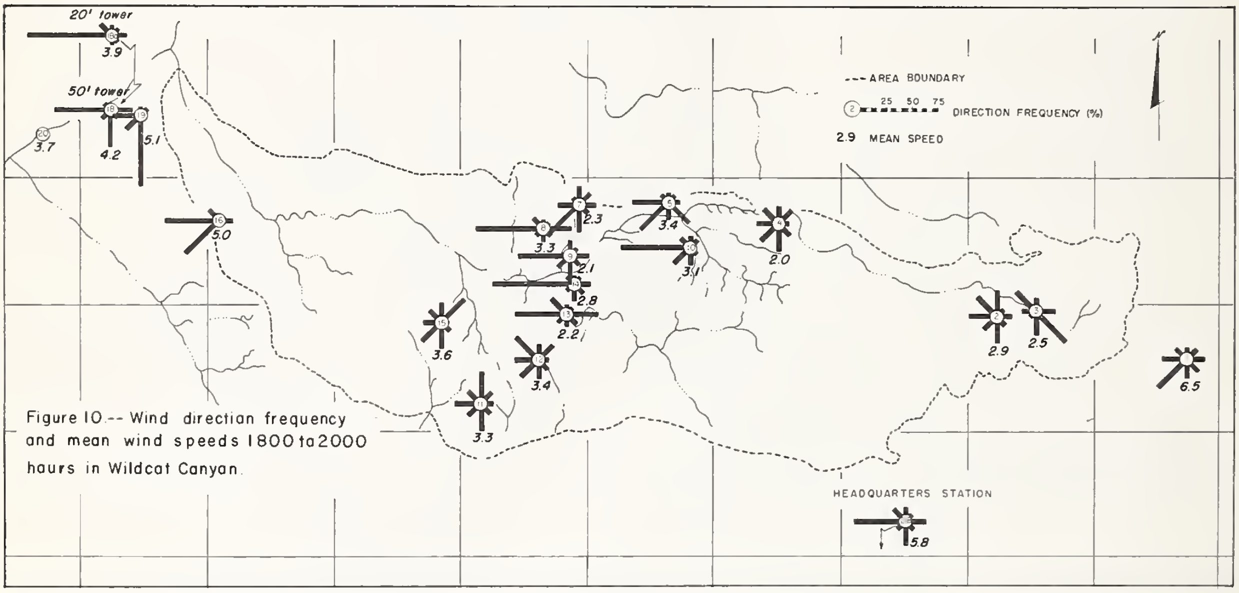

Figure 10.-- Wind direction frequency and mean wind speeds 1800 to 2000 hours in Wildcat Canyon.

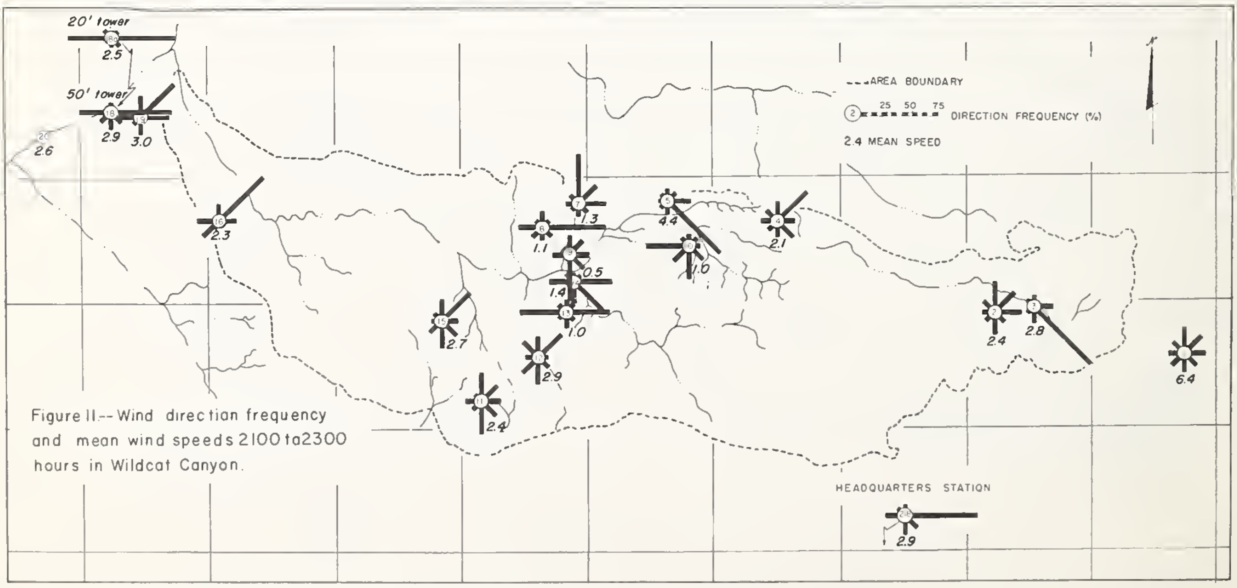

Figure 11.-- Wind direction frequency and mean wind speeds 2100 to 2300 hours in Wildcat Canyon.

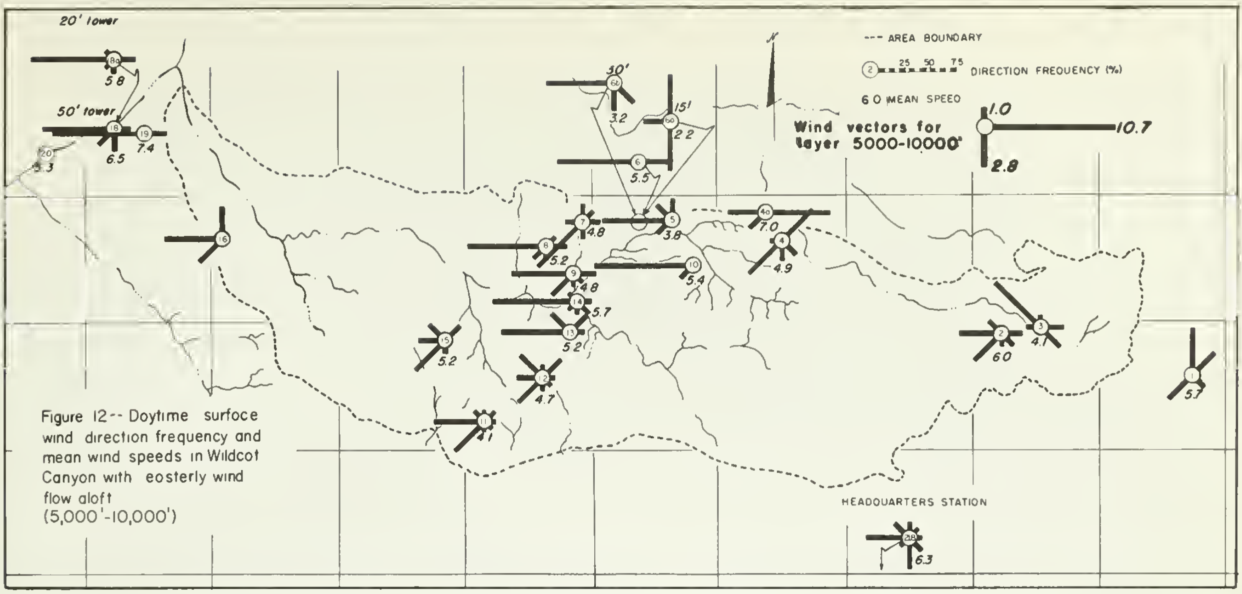

Figure 12 -- Daytime surface wind direction frequency and mean wind speeds in Wildcat Canyon with easterly wind flow aloft (5,000'-10,000')

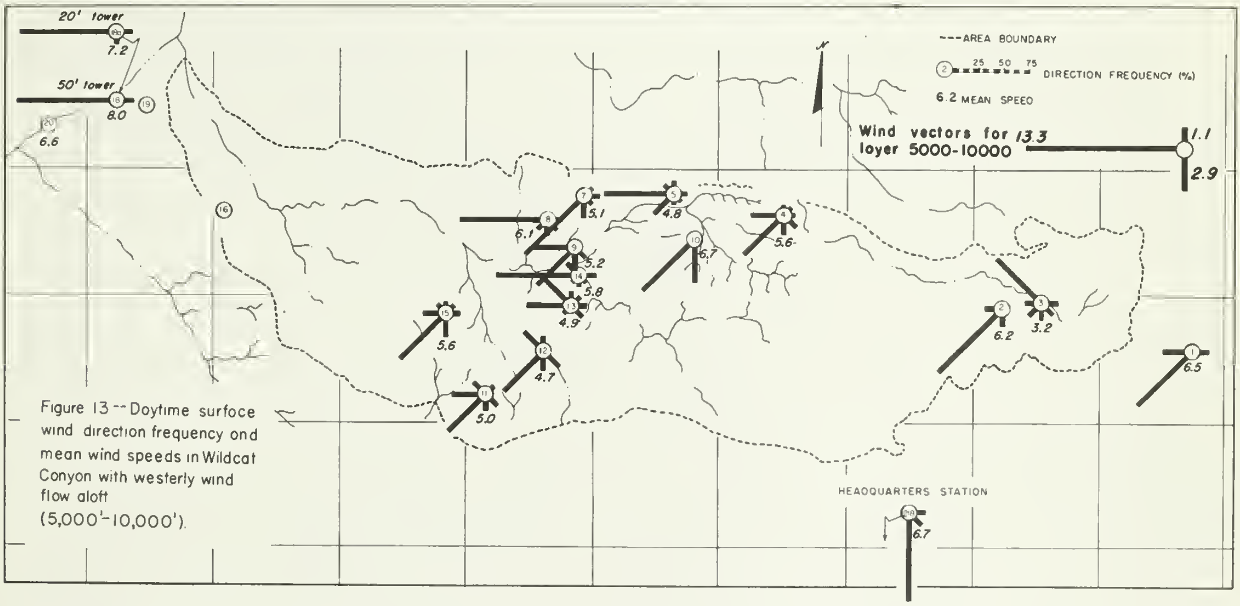

Figure 13 -- Daytime surface wind direction frequency and mean wind speeds in Wildcat Canyon with westerly wind flow aloft (5,000'-10,000').

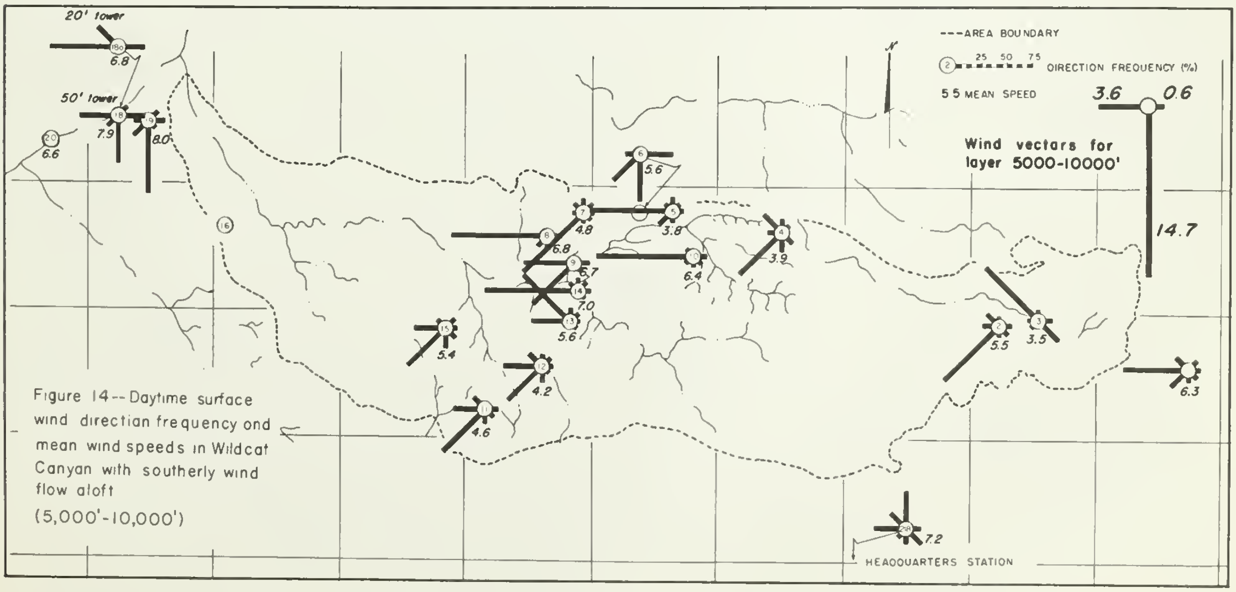

Figure 14 -- Daytime surface wind direction frequency and mean wind speeds in Wildcat Canyon with southerly wind flow aloft (5,000'-10,000')

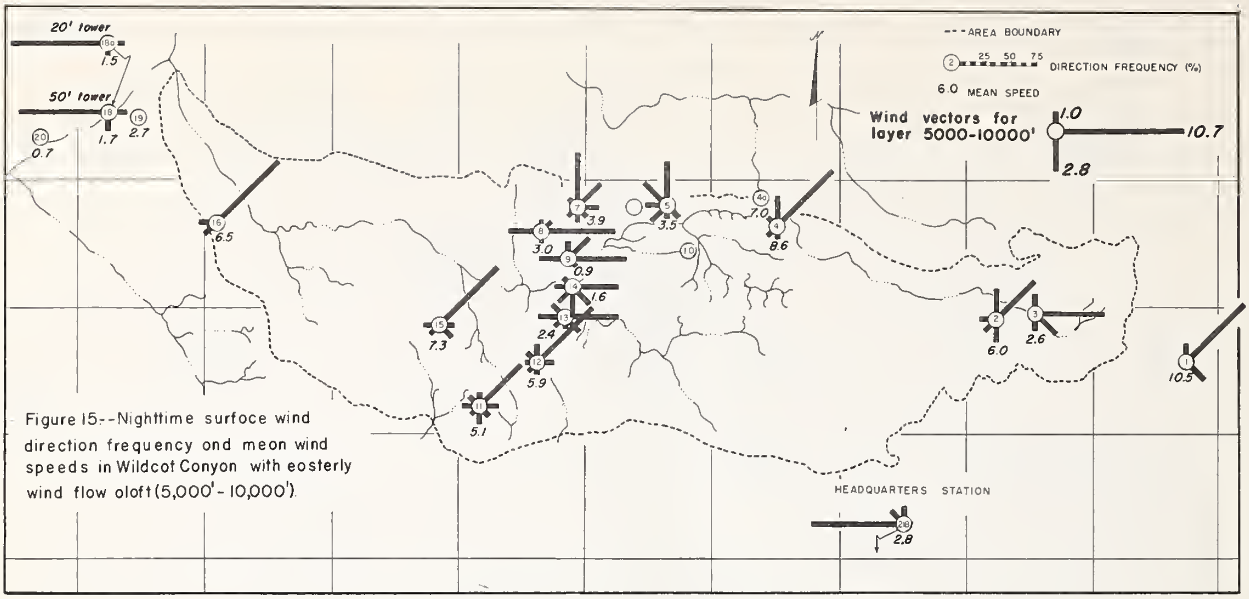

Figure 15--Nighttime surface wind direction frequency and mean wind speeds in Wildcat Canyon with easterly wind flow aloft (5,000'-10,000').

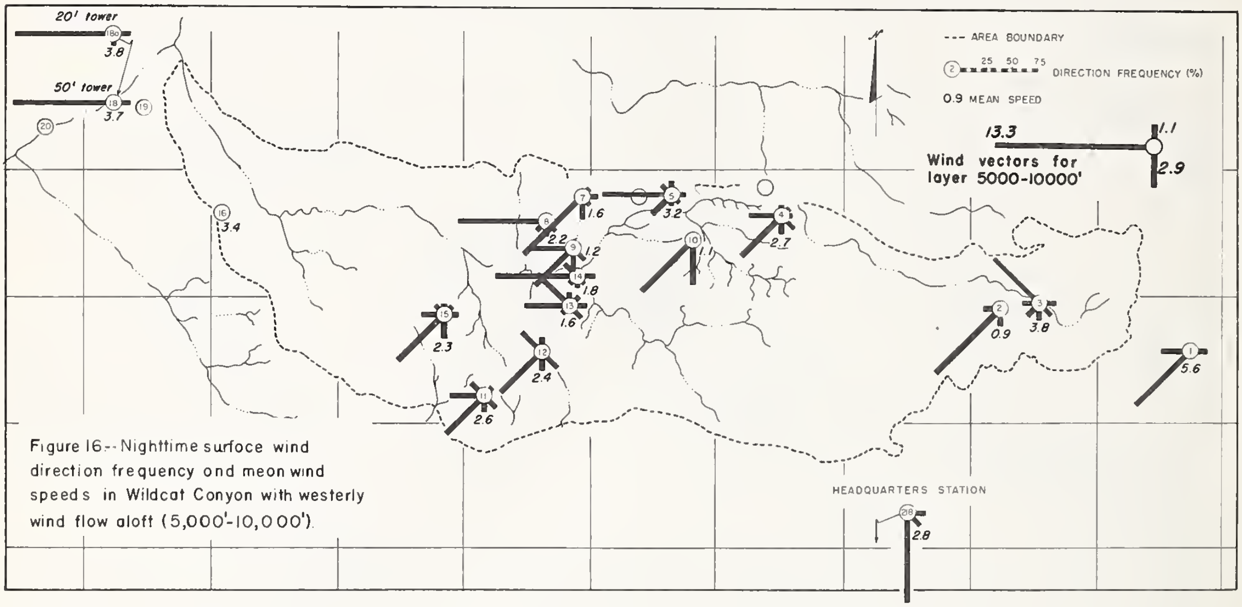

Figure 16--Nighttime surface wind direction frequency and mean wind speeds in Wildcat Canyon with westerly wind flow aloft (5,000'-10,000').

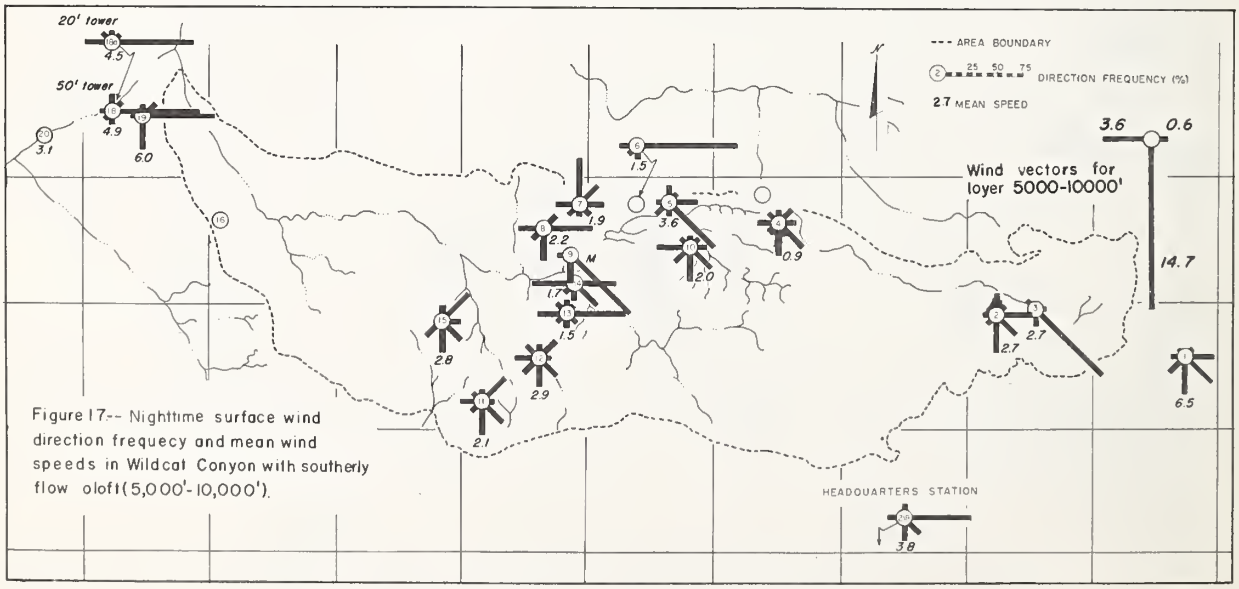

Figure 17-- Nighttime surface wind direction frequecy and mean wind speeds in Wildcat Canyon with southerly flow aloft (5,000'-10,000').

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